Harlequin Duck Research and Monitoring in Montana: 1999

A Report to:

ASARCO, Inc.
274 Union Blvd., Suite 450
Lakewood, Colorado 80228

Submitted by:
Paul Hendricks

March 2000

MONTANA
Natural Heritage
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ABSTRACT

In 1999, approximately 88 km of Harlequin Duck stream surveys were conducted on five streams, with the majority of effort focused on four Lower Clark Fork streams (Rock Creek, Swamp Creek, Marten Creek, Vermilion River). Additional streams surveyed were Trail Creek (North Fork Flathead River drainage) with one pair survey and one brood.

On the Lower Clark Fork streams, stream flow was normal during early-May pair surveys. A minimum of 22 adult Harlequins (12 males, 10 females) was seen on 3 streams. These included Marten Creek (4 pairs, 2 males, 1 female), Rock Creek (2 pairs), Vermilion River (3 pairs, 1 male) and Swamp Creek (no birds). The number of birds observed was about average for each stream and all streams combined, although Swamp Creek again had no birds.

Brood surveys were conducted during early August 1999. Only three broods were observed on the Lower Clark Fork streams (1 each on Marten Creek, Vermilion River, and Rock Creek), successfully producing a maximum 1 young on Marten Creek, 3 young on Vermilion River, and 5 young on Rock Creek. Age of broods indicated that nesting was more concentrated in time than during 1998.

New birds were banded on Marten Creek (1 female, 1 juvenile) and Rock Creek (4 juveniles). Additionally, several previously marked birds were re-observed, including 2 fourth-year females banded as juveniles in 1995 (1 of which successfully raised a brood on its natal stream). No inter-stream movements among the Lower Clark Fork streams were documented in 1999.

Stream survey results from Trail Creek (N. Fork Flathead drainage) were as follows: four pairs and 1 male counted on 16 May, no females or broods on 7 August.

ACKNOWLEDGMENTS

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INTRODUCTION

The Harlequin Duck (*Histrionicus histrionicus*) is a small sea duck, which travels inland to breed on fresh water streams. Approximately 150-200 pairs of Harlequins currently breed in Montana (Reichel and Genter 1995), with most located in the following areas: 1) tributaries of the lower Clark Fork River; 2) tributaries of the North, Middle, and South Forks of the Flathead River; 3) streams coming off the east front of the Rocky Mountains; and 4) the Boulder River (Miller 1988, 1989; Kerr 1989; Carlson 1990; Fairman and Miller 1990; Diamond and Finnegan 1992, 1993; Reichel and Genter 1993, 1994, 1995, 1996).

During the breeding season, Harlequins are found along fast mountain streams (Bengtson 1966, Robertson and Goudie 1999). In many areas, Harlequins use streams with dense timber or shrubs on the banks (Cassirer and Groves 1990), but they are also found in relatively open streams along the east slopes of the Rocky Mountains, Montana (Markum and Genter 1990, Diamond and Finnegan 1992), and in the Arctic tundra (Bengtson 1972). In Idaho, 90% of observations occurred near old growth or mature timber stands (Cassirer and Groves 1990). Mid-stream rocks, logs, islands, or stream-side gravel bars serve as safe loafing sites and appear to be important habitat components.

Most ducks arrive on their inland breeding areas in mid-April to early-May; unmated males typically arrive before pairs (Kuchel 1977). The males return to the coast shortly after the females begin incubation; most are gone by early July (Kuchel 1977). The females and young remain on the streams until August or early September. This chronology is influenced by elevation and by the timing of spring runoff; it may vary up to several weeks between years.

The Harlequin Duck is listed as "Sensitive" by the U.S. Forest Service, Region 1 (Reel *et al.* 1989) and as a Species of Special Concern by the Montana and Idaho Natural Heritage Programs (Idaho Conservation Data Center 1994, Montana Natural Heritage Program 1999).

The Montana Natural Heritage Program began banding Harlequin Ducks to a limited extent in 1991. Through 1998, a total of 391 Harlequin Ducks were marked on 9 streams, representing the largest marked "population" from the inland breeding grounds. Birds marked in Montana have subsequently been captured and observed on the coasts of Oregon, Washington and British Columbia, with most reports coming from Vancouver Island (Reichel and Genter 1996, Reichel et al. 1997).

Objectives for the 1999 season included 1) surveying the Lower Clark Fork streams (Rock Creek, Marten Creek, Swamp Creek, Vermilion River) of Sanders County for presence and status of Harlequin Ducks, 2) gathering duck productivity data on the Lower Clark Fork streams, and 3) marking as many individuals as possible on these streams for long-term monitoring. An additional objective was to survey Trail Creek (off of the N. Fork Flathead River), which appears to be an important corridor between Glacier National Park and the Pacific Coast.

This report summarizes results from the 1999 field season and should not be considered a comprehensive analysis of all data collected from previous years (although some of the older data are presented). For a recent and relatively comprehensive summary of Harlequin Duck research in Montana through 1996 see Reichel et al. (1997). The 1997 and 1998 field seasons are reported in Hendricks and Reichel (1998) and Hendricks (1999). An overview of Harlequin Duck biology is available in Robertson and Goudie (1999).

METHODS AND MATERIALS

Harlequin Ducks were surveyed in the Trout Creek-Noxon area of the Kootenai National Forest during May-August 1999. Area of focus included the four principal breeding streams of the Lower Clark Fork population in Sanders County, Montana. These Clark Fork River tributaries are Rock Creek, Marten Creek (including the S. Fork Marten Creek), Swamp Creek, and Vermilion River. Single pair and brood surveys were also conducted on Trail Creek (North Fork Flathead River) in Flathead County, as this stream might function as a movement corridor into Glacier National Park.

Surveys were conducted by walking the stream channel (when possible) or stream bank. In most cases, the surveyor walked upstream, giving more time to observe the bird before it moved out of sight; in cases where birds were not to be marked, the surveyor made a loop around the birds to minimize disturbance. For streams in the Flathead and Clark Fork drainages, we attempted to capture and mark all birds seen when a licensed, qualified bird-bander was present on the survey.

Captured birds were sexed, aged, weighed, measured (wing cord and tail), marked, and released. Juveniles were aged based on feather development: Class IA-C: downy (1-14 days old), no feathers visible; Class IIA-C: partly feathered (15-35 days old); Class III: fully feathered but flightless (36-51 days old). Birds were banded with a USFWS aluminum band and with a blue, plastic leg band with 2 white alpha alpha (juveniles) or alpha numeric (adults) characters. These birds are individually recognizable by the imprinted characters, although the bands are less readily observed than nasal discs, which were also used in years prior to 1997 but discontinued because of concerns about trauma and pairing success. Dates, locations, distance surveyed, and general characteristics of the stream reaches surveyed were recorded; location, number, age, and sex of all Harlequin Ducks seen were recorded, as were habitat characteristics of the sites where ducks were first observed. All surveys and duck observations were entered into a database and associated ARC-INFO coverages.

Not all streams used by Harlequin Ducks during the breeding season are used for nesting or brood rearing. Some streams where adult Harlequins are observed may be used only during migration to and from breeding areas. In order to classify Harlequin Duck observations in a consistent manner MTNHP has adopted the following definitions proposed by Cassirer et al. (1996) (the first two of which would be considered AðElement Occurrences@ð [EOs] by Natural Heritage Programs/ Conservation Data Centers throughout North America). See previous reports (Reichel and Genter 1996, Reichel et al. 1997) for a full discussion of the distribution of Harlequin Ducks throughout Montana, and the status and classification for each occupied stream or drainage.

Harlequin Duck breeding occurrence:

is defined by a drainage, drainages, or portion of a drainage where breeding is known (i.e., a brood or nest has been observed within the last 15 years).

EOs are separated by either:

- A substantial barrier (>2 km over a major divide); or,
- A 10-km separation for completely unsuitable habitat (across land);

. A 20-km separation (measured along watercourses) for both rarely used habitat (lakes, <1% gradient rivers) and for apparently suitable habitat that is not known to be occupied.

SURVEYS AND BANDING

MONTANA SURVEYS - 1998

In 1999 ca. 46.5 km of streams were surveyed for Harlequin Ducks (Figure 1); multiple surveys of the same streams were conducted on different dates. Thus, a total of ca. 88 stream km was surveyed in 1999 by MTNHP crews. Harlequin Duck pair surveys were conducted on 46.5 km of 6 streams by MTNHP crews: Rock Creek, Marten Creek, S. Fork Marten Creek, Swamp Creek, Vermilion River, Trail Creek (Flathead County). Glacier National Park personnel again conducted surveys, but those data are not included in this report. Brood surveys were conducted in August on 41.5 km of the same 6 streams.

Lower Clark Fork. A single pair survey was conducted between 5-10 May 1999 on each Lower Clark Fork stream (Rock Creek, Marten Creek/S. Fork Marten, Swamp Creek, Vermilion River). A minimum of 12 males and 10 females was observed on these four streams (Appendix 1). No adults were detected on Swamp Creek. Total numbers of ducks were about average on each of the major (four) streams except Swamp Creek. Swamp Creek has fluctuated between 0 and 3 females during 1992-1998. Water flow was near normal during pair surveys, with some lingering snowpack along upper portions of streams.

Brood surveys were conducted between 2-5 August 1999. Each of the four streams received a single survey. On the Lower Clark Fork streams, 1 female with 1 brood (5 young) was observed on Rock Creek. Based on the pair surveys of this stream, only 2 broods maximum were anticipated (see Appendix 1). No females and but 1 brood (1 young) were observed on Marten Creek, and 1 female and 1 brood (3 young) on the Vermilion River. Numbers of broods and young produced for the combined streams were at or near recorded lows during the period 1992-1999 (Appendix 3, Figure 2).

Previously marked birds identified in 1999 (see Appendix 2) in the Lower Clark Fork population included female blue TC on Rock Creek on 5 August (banded on Rock Creek on 26 July 1995). On Marten Creek, resighted birds on 6 May included male blue S8 (banded 10 May 1996), male aqua C7 (banded ? on the coast), and female blue SE (banded on 28 July 1995). On the Vermilion River, resighted birds included females blue X1 on 9 May (banded 29 July 1995), and females blue X2 and X3 on 8 May (banded on 31 July 1996 and 3 August 1998, respectively). A male with a \white band (black letters or numbers) was also seen on Vermilion River on 9 May.

Other Northwest Montana Areas. A pair survey was conducted along 5 km of Trail Creek (N. Fork Flathead River drainage, in Flathead County) on 16 May 1999. A minimum of 5 males and 4 females was observed. Confirmed resighted birds included two females with nasal markers that were marked on the coast on an unknown date (Appendix 2).

A brood survey was conducted along the same section of Trail Creek on 7 August 1999. No females or juveniles were encountered.

SUMMARY OF MONTANA SURVEYS 1987-99

In Montana, over 5000 km of streams have been surveyed since 1987 (Reichel and Genter 1996, Reichel et al. 1997). Many of these stream reaches have been surveyed in multiple years and during both pair and brood seasons. Not all of these streams can be considered adequately surveyed. To be reasonably sure birds are not present on a stream where no previous sightings have occurred, at least two surveys should be conducted during 1-25 May. If more than one pair survey is done in a single year, they should be done at least 1 week apart. Lack of knowledge of proper survey timing resulted in many surveys prior to 1992 being done during June (after males had left and females are incubating) or after 10 August when many birds in years of normal snow pack and runoff have left all streams but those in southwest Montana.

BANDING IN MONTANA: 1991-99

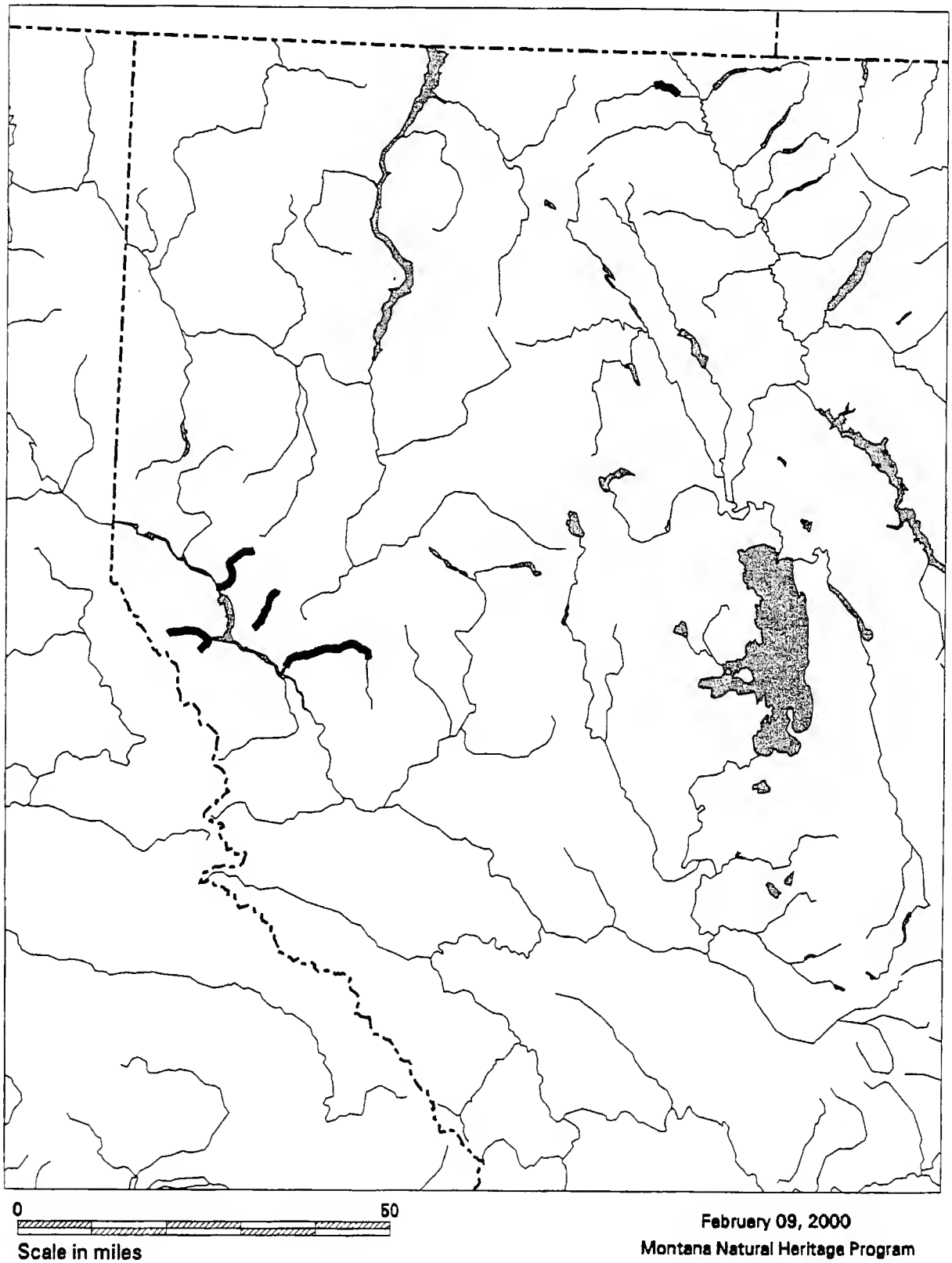
During 1999 in Montana, 1 adult female and 5 juveniles were captured and banded (Table 1); 1 male previously banded on the coast, and 1 female previously banded in Montana were also captured. This brings the total number of Harlequin Ducks banded since 1991 in Montana to 397 (61 males, 74 females, 262 juveniles).

Table 1. Summary of Harlequin Ducks marked for the first time in 1999 (total ducks captured in all years including 1999 are in parentheses).

Location	Male	Female	Juv.	Total
McDonald Creek drainage, Glacier NP	(27)	(32)	(81)	(140)
Waterton River, Glacier NP		(1)	(7)	(8)
Trail Creek*	(10)	(9)	(18)	(37)
Grave Creek		(3)	(6)	(9)
Spotted Bear River		(4)	(34)	(40)
Sullivan Creek, Flathead Co.		(2)	(10)	(12)
Cache Creek	(1)			(1)
Blackfoot River, North Fork		(1)	(2)	(3)
Marten Creek, Sanders Co.*	(17)	1 (8)	1 (44)	2 (69)
Rock Creek, Sanders Co.*	(4)	(5)	4 (19)	4 (32)
Swamp Creek, Sanders Co.*	(1)	(2)	(12)	(15)
Vermilion River, Sanders Co.*	(1)	(5)	(25)	(31)
TOTAL	(61)	1 (74)	5 (262)	6 (397)

* streams surveyed in 1999.

Figure 1. Streams surveyed for Harlequin Ducks in Montana in 1999, by the Natural Heritage Program.



MOVEMENT

ON THE BREEDING GROUNDS

In Montana and Idaho, several relatively long-distance movements have been documented both within and between years (Table 2). No between-drainage movements were documented in 1999, however. One inter-stream movement was documented in 1998, in the Lower Clark Fork drainage. A female banded as a juvenile on Swamp Creek on 27 July 1995 was observed with an unmarked adult male on 9 and 19 May 1998 on Rock Creek, a movement of about 21 km (along water courses, not a direct line). We have recorded movements between Marten Creek and the three other streams regularly surveyed in the Lower Clark Fork drainage (Rock Creek, Swamp Creek, Vermilion River), as well as with West Gold Creek in northern Idaho. The Swamp Creek to Rock Creek movement was the first between streams other than Marten Creek in this population. Marten Creek appears to be an extremely significant area for Harlequin Ducks of the Lower Clark Fork population, but some level of movement between all of these streams is likely, as indicated by the movement observed in 1998.

There is now supplemental data regarding the movement of a 1995 Rock Creek juvenile appearing on Marten Creek in 1997 (Table 2). The individual that made this movement (775-37376, blue TC: see Appendix 1 and 2) was captured back on Rock Creek (its natal stream) in 1998 and 1999. In both years this female produced broods. This indicates that some young females may explore other potential breeding streams in the year prior to first breeding, as apparently was the case with this individual.

The two longest movements to date were recorded in 1996. A female marked as a juvenile on West Gold Creek in Idaho in 1992 was found injured and without a brood on Marten Creek in 29 July 1996 (a 50 km movement). There have been no documented cases of females breeding on streams farther than 20 km from their natal stream (always within the same drainage), although the 1998 observation indicates breeding probably occurred on a stream other than the natal stream in the Lower Clark Fork population. The second long distance movement was a female marked on Grave Creek on 31 July 1996 without a brood and observed again, 75 km away, on McDonald Creek on 20, 22, and 28 August 1996 (Ashley 1997). This was likely a post-breeding exploratory movement or wandering during migration. Since no surveys had been done on Grave Creek since May of that year, it is unknown if she spent the summer there.

Both sexes of Harlequin Duck have been observed using different nearby drainages during different years in Montana and adjacent Idaho (Table 2). Two cases of within-year drainage change by adult females have also been noted. These observations indicate that movements of up to 30 km within an aggregate of streams may occur routinely but infrequently, both within and between years. Movements occurred over large reservoirs (Noxon Reservoir) and lakes (Lake McDonald). The 1995 movement by a female and her entire fledged brood to the Vermilion River was likely the result of disturbance due to marking. However, the movement took place at least 4 hours following the release of the birds. A breeding female (755-76025) in Glacier Park has been seen at several locations on different streams in the park over the 4 years since her banding (Ashley 1995); locations in Table 2 are the maximum distance moved during the 4 year period.

There is little published literature regarding movement within the breeding grounds. Kuchel (1977) found that pairs used lower McDonald Creek prior to establishing home ranges higher up along the stream. Once established, pairs rarely moved more than 1-2 km, although movements of up to 8

km were recorded. Kuchel (1977) found unpaired males moved considerably more during the breeding season, with movements of up to 10 km recorded. In a reanalysis of Kuchel=ðs (1977) data, Cassirer and Groves (1992) found that linear home ranges during the breeding season averaged 7.7 km (*SD* = 2.34) on McDonald Creek, similar to the 7 km reaches used in Idaho.

Table 2. Significant movements of Harlequin Ducks within and between years on the breeding grounds in Montana and Idaho (Cassirer and Groves 1994, Reichel and Genter 1994, 1995; Ashley 1995, 1996; Reichel et al. 1997; Hendricks and Reichel 1998; Hendricks 1999; Cassirer pers. comm.).

Age and sex when banded	1st Date	Location	2nd Date	Location	Km moved
Adult Male	1990	Gold Creek, ID	1991	Granite Creek, ID	14
Adult Male 755-76075	5/26/93	Marten Creek, Devils Gap	4/27/95	Vermilion River, 0.1 mi above Miners Gulch	31
Juv. Female 805-90262 changed to 925-09364	8/10/92	West Gold Creek at Lake Pend Oreille, ID	7/29/96	Marten Creek, near mouth	50
Adult Female 755-76007	8/4/92	Marten Creek, mouth of (w/ brood)	7/30/93	Swamp Creek, T25N R31W Section 9 (w/ brood)	16
Adult Female 755-76025	8/10/92	McDonald Creek above McDonald Lake (w/ brood), Glacier N.P.	6/29/95	Middle Fork Flathead River (w/ brood)	18
Adult Female 755-76013	7/28/95	Marten Creek, near mouth (with 6 young 925-09336, 37, 38, 39, 40, 41	7/29/95	Vermilion River, near Sims Creek confluence (with same 6 young) T	26
Adult Female 925-09374	7/31/96	Grave Creek, 0.7 mi above Cat Creek, Lincoln Co.	8/20/96	McDonald Creek, near McDonald Falls, Glacier National Park	75
Juv. Female 775-37376	7/26/95	Rock Creek, T26N R32W S22SE	8/9/97	Marten Creek, near Devils Gap	21.5
Juv. Female 775-37379	7/25/95	Swamp Creek, T26N R31W S34SESWSW	5/9/98 and 5/19/98	Rock Creek, T26N R32W S27NWNE (paired, probably raised a brood)	21

On the Bow River in Banff National Park, 5 pairs of birds were marked at what is probably a staging area or local migratory corridor (Smith 1996). Two pairs remained in a 2 km section of river where they were banded, and another remained in a 2 km stretch about 12 km downstream; one pair remained within about 6 km until the female moved about 8 km up a drainage, perhaps to breed; the final pair moved about 15 km downstream within 22 days (Smith 1996).

For 35 Harlequins marked in Iceland, Bengtson (1972) found no movement between breeding streams and movement of only a few km within drainages. Not only did the birds return to the same drainage, but in 22 out of 33 cases, the birds were observed within 100 m of their locations during the previous year (Bengtson 1972).

MIGRATION

Nature of migration. All inland populations of Harlequin Duck migrate to and from coastal waters (Robertson and Goudie 1999). Pairing takes place on the coast prior to migration on the breeding grounds, perhaps at staging areas first (Wright et al. 1998, Robertson and Goudie 1999). In Iceland, birds are thought to swim up the rivers from the coastal wintering grounds to the freshwater breeding sites (Gudmundsson 1961 *in* Bengtson 1966).

Fall movement to the coast by females and juveniles may be relatively rapid. A marked female seen on Granite Creek, Idaho on 17 July 1991 was relocated 13 days later near Battleship Island in the San Juan Islands, Washington (Cassirer and Groves 1992). Sibling juveniles may migrate together to the coast, as indicated by the presence of 3 siblings at Hornby Island, B.C. (Harlequin Duck Working Group Database, G. Schirato, Wash. Dept. Fish & Wildlife pers. comm.) which were marked together 7 months earlier on Swamp Creek, Montana. Whether females and their broods migrate together in some instances is unknown, although some females arrive on the coast with their young (Cooke et al. 2000). However, it is known that females occasionally leave prior to their young fledging. In Montana, out of 138 broods observed during 1988-9, 17 broods (12.3%) were found without the hen prior to migration (Reichel et al. 1997, Hendricks and Reichel 1998, Hendricks 1999, Ashley pers. comm.). Age class of the 17 abandoned broods when they were first observed alone was as follows: 2 were Class I, 4 were Class II, 3 were Class III, and 8 broods were first observed without the adult female following fledging. In one additional case, a brood of 7 was marked with the female on 11 Aug 1992; on 2 September the female was seen with 5 of her fledged juveniles, while one of the brood was observed alone 2.5 km away.

Adult males apparently return to coastal sites shortly after breeding (June-July), where they complete prebasic molt by August, and then under go pre-alternate shortly thereafter (Cooke et al. 1997), attaining alternate plumage by October. Pair formation begins at this time and extends well into winter (Robertson et al. 1998a). Although timing of molt was not related to pairing success, males that molt quickly into the bright alternate plumage have a higher probability of pairing with females in the winter and spring coastal aggregations (Robertson et al. 1998b). Pair bonds tend to last the lifetime of the members of a pair ((Smith et al. 2000).

Coastal wintering sites. Of 249 Harlequins banded in Montana from 1991-1995, a minimum of 24 have been reported from Oregon (2), Washington (1), and southern British Columbia (21) through September 1996 (G. Shirato pers. comm.). Sexes and ages at banding show the following

numbers and percentages observed: adult females (6, 11%), adult males (2, 5%), juvenile females (9, 7%), and juvenile males (7, 5%).

Birds banded during 1996-1999 are not included in the above summary of resighting records for birds marked in Montana. Nevertheless, during 1997 to January 2000 more than 30 individuals banded in Montana have been reported from British Columbia (Vancouver and Hornby islands) and at least 3 birds from Washington (Harlequin Duck Working Group pers. comm., numerous observers). Resightings include 7 adult males, 6 adult females and 2 juveniles from the Lower Clark Fork streams: Rock Creek (2 males, 1 female, 2 juveniles), Swamp Creek (3 males, 2 females), Marten Creek (1 male, 1 female), Vermilion River (1 male, 2 females). Female VA, the Swamp Creek bird seen paired on Rock Creek in May 1998 (Table 2) and probably producing a brood on Rock Creek, was reported off Vancouver Island, British Columbia on 11 September 1998 (Ken Wright pers. comm.). Female X1, reported in May of 1998 and 1999 on the Vermilion River was reported at Seattle throughout the winter of 1998/1999 to 16 March 1999 and again on 15 October 1999 at the same locality (I. McGregor pers. comm.).

Additional coastal resightings during 1997-1999 for birds banded on other Montana streams included McDonald Creek (8 males, 4 females, 1 juvenile), Trail Creek (1 male), Spotted Bear River (1 female) and North Fork of the Blackfoot River (1 male, 1 female).

Migratory behavior. It is believed that nearly all one-year-old birds, and some (perhaps most) two-year-old birds remain in coastal water, not moving to breeding streams until they are 2-4 years of age (Robertson and Goudie 1999). The proportion of each age class that stays on the coast has yet to be determined, but indications are that one-half of 2-year-old females and one-quarter of 3-year-old females do not return to the breeding grounds. Five 2-year-old females were seen during 1997 surveys of the Lower Clark Fork streams. Four of these females were on their natal stream (Marten Creek) and 3 were siblings. The fifth female was born on Rock Creek and was encountered on Marten Creek (see Table 2). No two-year-old males or females were noted during the 1999 surveys. Wallen (1987) reported that a 1-year-old female (of 11 total) returned to her natal stream (Upper Moose Creek) in Grand Teton National Park in 1986. This is the only report of a 1-year-old female on the breeding grounds. No one- or two-year-old males, out of 246 observations of males, have been seen in Montana during 1992-96 surveys (Table 7, Ashley pers. comm.).

DEMOGRAPHY AND POPULATIONS

MEASURES OF BREEDING ACTIVITY

Age at first breeding; intervals between breeding. Only a single known-aged male has been seen with a mate; it was marked by MTNHP as a juvenile in 1992 on Mineral Creek (Glacier National Park), Montana, and observed by J. Ashley paired with a female (white NH) at Hornby Island, BC, in March 1996. Adult male breeding plumage is attained at three years of age (Phillips 1925). No one- or two-year-old males, out of 246 independent male observations, have been observed in Montana during 1992-96 surveys (Ashley pers. comm.).

The youngest female known to have bred is a 2-year-old that raised a brood of 3 in 1994 on Trail Creek, Montana. Several 3-year-old females have bred successfully in Montana, including 4 in 1998 (TC on Rock Creek and probably VA; SA and SC on Marten Creek). Two 4-year-old females are known to have bred successfully, through 1999 (on Marten Creek in 1996 and TC again on Rock

Creek in 1999). One 5-year-old female is known to have bred successfully on her natal stream (McDonald Creek in 1997).

Some females on breeding streams apparently do not lay eggs (Bengtson and Ulfstrand 1971, Dzinbal 1982, Wallen 1987, Cassirer and Groves 1991). Bengtson and Ulfstrand (1971) examined ovaries of 6 non-breeding females and reported that none had laid eggs. They reported that 15-30% (n=48) of adult females (based on bursae inspection) were non-breeders. Many of these non-breeding Aðadults@ð may have been young (2-3 year-old) birds, since cloacal examination gives adult status to 2-year-olds.

Annual and lifetime reproductive success. Reproductive success in Montana was below average in 1999, with one of the lowest number of broods and young per female recorded on many Lower Clark Fork streams (Figure 2, Table 3, 4). Values for all streams surveyed in 1999 (0.21 broods per female, 0.64 young per female, 3.00 young per brood) were similar to values for 1991 (Table 4: 0.24 broods per female, 0.84 young per female, 3.44 young per brood, although 1999 produced fewer broods and young.

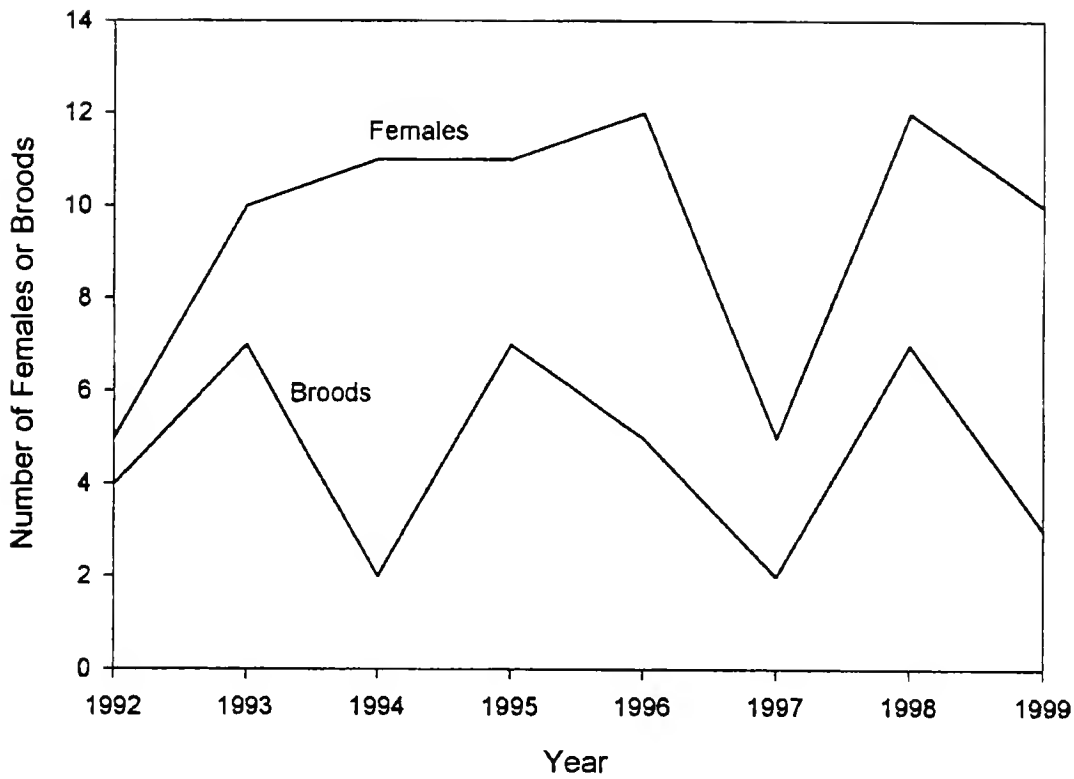
The data for 1999 and other years (Table 4) are not directly comparable, however, because not all streams represented in the pooled annual survey data were identical. Streams with the largest duck populations have the greatest influence on mean values, and there is no evidence that production on any single stream or subset of streams is typical each year for all breeding streams in the state. Pooling results for the entire state, as presented in Table 4, also masks fluctuations for particular streams or drainages. This is especially evident for the Lower Clark Fork streams (Appendix 3). Each of these streams has experienced at least one year during 1992-1998 where no broods were produced, but in only one year (1992) did the majority of streams fail to produce broods. Interestingly, during that year Marten Creek produced more broods (4) than in any other year for which there are data.

Until data are available on age-specific reproduction and longevity, no lifetime reproductive success can be calculated. Therefore, this has not been calculated for any Montana population.

Proportion of females that rear broods to nest-leaving. Harlequin Ducks raise only a single brood each year. The proportion of females successfully raising a brood in a single year varies widely between years (Table 4). In Montana during 1999, 21% of 14 females successfully raised a brood on surveyed streams. Stream surveys between 1974 and 1999 found that 423 females raised 154 broods for a total 36% of females with broods (range 7-55%), and an annual mean of 33% for 13 years of data. Throughout their range, the percentage of females which successfully raise broods varies from 7-56% (Bengtson and Ulfstrand 1971, Kuchel 1977, Wallen 1987, Cassirer and Groves 1991, Reichel et al. 1997, Robertson and Goudie 1999).

Sex ratio. In 1999 on the Lower Clark Fork streams, we counted 12 males and 10 females during May pair surveys. Sex ratio on these streams was 1.20:1 (m:f) in 1999. During the spring pair season for all years combined through 1997, a sex ratio of 1.49:1 has been observed in Montana (m:f, n =850; 509 males:341 females). These values are based on independent male observations during the period 27 April - 31 May and the maximum number of females seen when more than one survey was done during a single season on a single stream (see Reichel et al. 1997 for more details). Cassirer (1995) found a spring adult sex ratio of 1.31:1 (m:f, n = 81) in 1995 on Idaho streams. In Banff National Park, Alberta, sex ratios varied from 1.37:1 in May to 1.81 in June (Smith 1996). In Iceland, sex ratios on the breeding grounds varied from 1.17 - 2.33:1 during 5 summers in late May - early June (Bengtson 1966, Bengtson 1972, Gardarsson 1979).

Figure 2. Numbers of females and broods recorded for the four monitored streams of the Lower Clark Fork River population, 1992-1999. Streams surveyed include Rock Creek, Marten Creek (and S. Fork Marten Creek), Swamp Creek, and Vermilion River.


14
12
10
8
6
4
2
0
Number of Females or Broods
Females
Broods
1992
1993
1994
1995
1996
1997
1998
1999
Year

In coastal British Columbia, the apparent sex ratio is 1.5:1 (544 birds) in winter, declining from to 1.4:1 (297 birds) in March-April (Campbell *et al.* 1990); this grows to 4.3:1 in May, and by July, when adult females are still on the breeding streams, it reaches 18.2:1 (n = 1633 birds).

Table 3. Harlequin Duck reproduction in 1999 for Montana streams with both pair and brood (near fledging) surveys.

Stream	#Adult Females	#Broods	#Young
Flathead Drainage			
Trail Creek	4	0	0
Drainage Total	4	0	0
0.00 Broods per adult female			
0.00 Young per adult female			
0.00 Young per brood			
Lower Clark Fork Drainage			
Marten Creek	5	1	1
Rock Creek	2	1	5
Swamp Creek	0	0	0
Vermilion River	3	1	3
Drainage Total	10	3	9
0.30 Broods per adult female			
0.90 Young per adult female			
3.00 Young per brood			
GRAND TOTAL	14	3	9
0.21 Broods per adult female			
0.64 Young per adult female			
3.00 Young per brood			

FIDELITY TO BREEDING STREAMS

Adult fidelity to breeding stream. In Montana, 391 Harlequins (61 adult males, 73 adult females, 257 juveniles) have been banded from 1991 through 1998 (Table 1). In 1998, 3 males and 12 females originally marked as adults were resighted on the streams on which they had be banded in a previous year (Appendix 2). This figure includes females in Glacier National Park, but not males. Streams included Marten Creek (3 males), Vermilion River (2 females), Trail Creek (2 females), and McDonald Creek (8 females). Through 1996, 60% of males (25 of 42) and 64% of females (36 of 56) returned at least 1 year following marking. Figures have not yet been calculated using 1997-1998 data.

Lower return rate of males may be a result of mating with new females on the coast and following them to female natal streams.

Fidelity to natal stream. In 1999, two 4-year-old females returned to natal streams (Rock Creek and Marten Creek) and one is know to have successfully raised a brood.

Table 4. Harlequin Duck reproductive parameters 1974-75 (Kuchel 1977) and 1989-1999 for Montana streams with both pair and brood surveys.

Year	No. adult females	No. broods	No. young	broods per ad. Female	young per ad. Female	young per brood
1974	11	3	12	0.27	1.09	4.00
1975	15	1	2	0.07	0.13	2.00
1989	13	7	41	0.54	3.15	5.86
1990*	31	17	65	0.55	2.10	3.82
1991*	37	9	31	0.24	0.84	3.44
1992*#	71	39	132	0.55	1.37	3.38
1993#	49	21	59	0.43	1.20	2.81
1994#	30	10	40	0.33	1.33	4.00
1995#	48	11	42	0.23	0.87	3.82
1996 *#	44	14	56	0.32	1.27	4.00
1997#	28	6	25	0.21	0.89	4.17
1998#	32	13	55	0.41	1.72	4.23
1999	14	3	9	0.21	0.64	3.00
Total	423	154	569	0.36	1.35	3.69
Annual mean±SD				0.33±0.15	1.28±0.75	3.73±0.90

* includes data from the Rocky Mountain Front (Diamond and Finnegan 1992, 1993; D.Whittekeind, pers. comm.)

includes data from Ashley (1994a, 1994b, 1995, 1996, 1997, pers. comm.)

CONSERVATION AND MANAGEMENT

IMPLICATIONS OF THE CURRENT RESEARCH

This section essentially restates what has already been presented in previous reports (e g., Reichel et al 1997, Hendricks and Reichel 1998, Hendricks 1999). These comments are worth presenting again to emphasize that many populations continue to be exposed to serious threats. Much of what is known about the life history highlight the precarious nature of the populations in the

Rocky Mountains of the United States. Factors that limit recolonization and increase the possibility of extirpation include: 1) high female natal site fidelity; 2) high adult site fidelity; 3) pair bonds developing on the wintering grounds; 4) low levels of movement on the breeding grounds; 5) relatively advanced age at first reproduction; 6) little chance of renesting after about 2 weeks following the start of incubation; 7) low and irregular levels of reproductive success; 8) patches of suitable habitat which are highly fragmented; 9) sensitivity to disturbance; 10) the clumped distribution of pairs, even in apparently homogeneous habitat; 10) declining range-wide and regional population levels; 11) relatively small and isolated regional populations; and 12) use of coastal wintering habitat immediately offshore (often less than 100 m).

Harlequin Ducks apparently form pair bonds on the coast. Females apparently lead their mates to the breeding streams. Site fidelity is high, both for first-time and experienced breeders, and probably exceeds 90% for both categories. This leaves very few birds to explore and Aðpioneer@ð new sites. Harlequin Ducks may key in on areas with other ducks present, like many other bird species with clumped distributions. In other words, good habitat to a Aðpioneer@ð is where ducks are already present; empty habitat would be unlikely to be colonized. Suitable habitat in the Rocky Mountains is currently sparse and widely separated. Much has probably been lost and fragmented by alteration of stream-side land and building of reservoirs.

Small breeding populations face several challenges. Random events, such as several birds dying or several poor reproductive years caused by flooding, can dramatically reduce already small populations or eliminate them. Females do not breed until 2 or more years-old and adult success rates may not occur until 4 or more years-old. This means that mortality must be low or few ducks will even make it to breeding age. Once a duck attains breeding age, it can only produce a single brood each year. While many bird species renest when the nests or young are lost, there is little possibility of Harlequins renesting after more than a week or two following egg laying. Males return to the coast a week or two after the females begin incubation. The result of the above factors is that reproductive success is low and highly variable. An average female is probably 4 or 5 years old before she has raised even 2 female ducklings to fledging. It is likely that mortality in the first 6 months following fledging is high.

Harlequins from the U.S. Rocky Mountains move to the Pacific coast off Oregon, Washington, and British Columbia following breeding and remain there until the following spring. They are concentrated in areas with rocky shorelines. Harlequins are the most coastal of wintering sea ducks and are thus more susceptible to hunting and oil spills than most sea ducks.

This set of facts does not bode well for the Harlequin Duck in Montana, where 10 of 27 occurrences consist of only 1 or 2 pairs of ducks. It also shows the critical nature of the 6 occurrences with more than 15 pairs as a source of stability to the Rocky Mountains regional population.

PRIORITIES FOR FUTURE RESEARCH

The following are among the top future research priorities and are primarily a subset of those listed

by the Harlequin Duck Working Group (1993) and by Cassirer *et al.* (1996).

1) What are the impacts of human disturbance on breeding and wintering Harlequin Ducks?

Several independent studies have documented the sensitivity of Harlequin Ducks to human disturbance, primarily through the relationship of sighting locations to the accessibility of those locations (Kuchel 1977, Wallen 1987, Diamond and Finnegan 1993, Cassirer and Groves 1991, 1994, Clarkson 1992, Ashley 1994). Specifically, boating has been shown to have a significant negative correlation with numbers of ducks present in one area on a medium-sized stream (Clarkson 1992, Hunt 1993). Observations in other areas tend to support this conclusion (Cassirer and Groves 1991, Brady pers. comm. *in* Clarkson 1992) though it may not be the case in very large streams (Smith 1996, 1999). Fishing and human presence have also been suggested as causes of disturbance. However, although specific examples exist for both disturbances, statistical data analyses are lacking (Wallen 1987, McEneaney 1994, Cassirer and Groves 1991).

Other than for boating (Clarkson 1992, Hunt 1993), wide-scale analyses have not yet been attempted nor have analyses of the effects of most specific kinds and amounts of human activities. Several specific studies should be performed to address these questions.

Initially, wide-scale data on Harlequin streams are required. Data needed on the ducks themselves include productivity and population size on each stream. Data needed on the streams used by Harlequin Ducks include length of stream segments used during pair and brood seasons, categories and locations of land ownership, hydrogeological properties, habitat characteristics, and current human use (by roads, trails, structures, activity, etc.). A first step will be to see which of this information is already available and which is lacking that needs gathering in the field. Unused and/or unknown streams that fit physical parameters of used streams can then be selected and compared in respect to kind and amounts of disturbance/accessibility.

Following wide-scale analyses, Harlequin response to humans requires evaluation. Initial responses to surveyors could be recorded. Note that this would only provide immediate, in-sight response of birds seen. Presumably some birds would react prior to the surveyor seeing them and thus not be observed at all. Nor would such a study reveal length of time or distance moved in reaction to disturbance. A more precise but intrusive method would be to use radio-telemetry on the birds. Radio-telemetry would also provide more accurate data on use of habitat types and locations relative to human development/access points.

Finally, when actions are taken on Harlequin streams, monitoring to determine effects of those actions should be implemented, thereby providing for adaptive management and prevention of future mistakes. Specific land management or development actions on Harlequin streams should be proceeded by at least two years of baseline marking and surveying for population size and productivity, areas used at different seasons, habitat evaluation, and pre-action levels of human activity and development. Monitoring should continue to occur during and following the action. Actions needing special attention include road, campsite, and trail construction activity, including any increased accessibility and changes in human use of the area. Actions that might result in changes to flow regimes or water quality include mining, road building, timber harvest, industrial development,

and water/hydroelectric development. Also requiring attention are changes in fishing regulations, which could alter fisherman impact on an area, and building of structures, such as industrial areas, dams, or houses, which will increase access to and use of a Harlequin stream. Possibilities for mitigation and habitat restoration can be explored during these projects.

2) What is the extent and nature of movements in breeding and wintering areas?

This information is needed to determine the possibilities for natural recolonization of new and historic Harlequin occurrences, natural supplementation of existing occurrences, particularly small populations, and the strength of natal and adult fidelity to particular sites. This information is necessary for successful modeling of Harlequin populations and their stability, using both breeding and wintering ground data.

Radio-telemetry may give quick results from the standpoint of local daily movements (see Smith 1999); however, long distance (>5 km) movements may be relatively rare, and with limited numbers of ducks radioed, may not be best for long distance movement detection. For long distance and moves between years, visibly marking birds is best.

Determining fidelity to natal areas will be a long-term project. Montana has the strongest start, with 397 birds banded on the breeding grounds since 1992. Data so far indicate high fidelity to natal streams.

Much data is now available in relation to wintering ground movements and fidelity, and additional data is currently being collected in Washington, Alaska, and British Columbia. Sufficient information for use in detailed population modeling is currently being processed (Robertson pers. comm.). For an accurate model, data are necessary from both the breeding and wintering grounds.

3) Are distinct metapopulations (such as a Rocky Mountain breeding population) identifiable within the Pacific range of the Harlequin Duck?

Knowledge of the degree of genetic differences among and within wintering and breeding subpopulations would allow an assessment of the appropriate management units for various Harlequin conservation strategies. Dan Esler, Alaska National Biological Service, and Maggie Brown (Department of Wildlife, Fish and Conservation Biology, University of California - Davis) are currently examining this question (see Brown 1998).

4) What are the critical habitat components limiting Harlequin Duck breeding and wintering populations?

Harlequin Ducks use a wide variety of habitats on the breeding grounds, from forests to tundra. Habitat usage should be documented over a large number of study areas to identify common habitat components for comparison to available habitat; both large and small scale components should be considered.

5) How and why do productivity and survival change over time and different areas, and what are

the relative impacts of these changes on populations?

Long term studies are needed to determine population parameters for incorporation into population models (with information from movements on the breeding and wintering grounds). Needed population parameters include: productivity; age-related survival; recruitment; age(s) at first breeding and/or successful breeding; age(s) last breeding; life expectancy; and causes and timing of mortality. This information will be acquired only through long-term studies involving marked birds on both the breeding and wintering areas. We are currently in an optimum position to complete studies needed on the breeding grounds, with 7 years of data on portions of the Montana breeding population. Combined with the continued marking and study of coastal populations by Alaska, Washington, Oregon, and British Columbia, and interior populations in Alberta, many of these parameters may be known in the next few years.

The most difficult question to be answered involves the causes of mortality, which is not tractable given current technology. If and when small, long range mortality transmitters are available for ducks, this topic should be pursued. Some females are killed on nests (Smith 1999) by predators, but the significance of predation is not yet clear.

6) What are the characteristics of Harlequin Duck migration? How well defined are migratory staging areas and migration corridors?

This question may not be tractable given current technology. When small, long range mortality transmitters are available for ducks, this topic should be pursued. Some answers may come from large scale marking of individuals, and perhaps by relocating radioed birds. We still have few reports of Harlequin Ducks moving between the coast and inland breeding areas. Nor do we know routes of movement on a smaller landscape scale. For example, Harlequin Ducks that breed on the east slope of the Continental Divide must cross the Divide on their movements to and from the coast, but where do they do so? Do certain drainages serve as "funnels" for most ducks in local populations during migratory movements?

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Appendix 1. Results of Harlequin Duck surveys in 1999 on the Lower Clark Fork tributaries. M and F in comments refer to resighted previously-banded males and females (usually with blue color bands); juvenile age classes are as described in the methods.

STREAM	DATE	PAIRS	MALES	FEMALES	BROODS	YOUNG	COMMENTS
Rock	7 May	2	—		—	—	
Creek	5 Aug	—	—	— 1	1	5	F:TC, 5 IIC juvs.
Marten	5/6 May	4	2		—	—	M:aqua C7, S8; F:SE
Creek	2/3 Aug	—	—	1 —	1	1	1 IIB juv.
Swamp	10 May	—	—		—		No ducks
Creek	3 Aug	—	—	— —	—	— —	No ducks
Vermilio	8/9 May	3	1		—	—	M: white ?; F:X1,X2,X3.
n River	4 Aug	—	—	1 —	1	3	F: blue ?; 3 IIB juvs.

Appendix 2. Previously banded Harlequin Ducks observed in northwestern Montana during 1999 MTNHP surveys.

Stream where Resighted	Band No.*	Sex	Date first Resighted	Stream where Banded	Date Banded	Age when Banded
Rock Cr.	TC	F	5 Aug	Rock	26 Jul 95	Juv.
Marten Cr.	S8	M	6 May	Marten	10 May 96	Adult
Marten Cr.	SE	F	6 May	Marten	28 Jul 95	Juv.
Marten Cr.	Aqua C7[1]	M	6 May	coast	?	?
Vermilion R.	X1	F	9 May	Vermilion	29 Jul 95	Adult
Vermilion R.	X2[2]	F	8 May	Vermilion	31 Jul 96	Adult
Vermilion R.	X3	F	8 May	Vermilion	3 Aug 98	Adult
Vermilion R.	White ??	M	9 May	coast	?	?
Trail Cr.	O-ro,C-r[3]	F	16 May	coast	?	?
Trail Cr.	C-r, T-ro[3]	F	16 May	coast	?	?

* Blue color band, unless indicated otherwise.

[1] Aluminum band 925-23787.

[2] Aluminum band 925-09393. Color band added in 1998.

[3] Nasal markers: O=oval, C=circle, T=triangle, r=red, ro=rose. Sequence is left-right.

Appendix 3. Annual productivity of Harlequin Ducks during 1992-1999 on the four Lower Clark Fork streams of Sanders County, Montana.

STREAM	1992	1993	1994	1995	1996	1997	1998	1999
Marten Creek								
No. adult females	4	5	5	5	5	3	7	5
No. broods	4	2	0	2	2	1	2	1
Broods/female	1.00	0.40	0	0.40	0.40	0.33	0.29	0.20
Young/brood	3.25	4.00	0.00	5.5	2.5	6.00	5.5	1.0
Rock Creek								
No. adult females	0	2 (?)	4	1(?)	3	1	3	2
No. broods	0	2	1	1	0	1	3	1
Broods/female	0	1.00	0.25	1.00	0.00	1.00	1.00	0.50
Young/brood	0.00	3.00	3.00	5.00	0.00	6.00	4.33	5.00
Swamp Creek								
No. adult females	0	1	0	3	2	0	0	0
No. broods	0	1	0	2	2	0	0	0
Broods/female	0.00	1.00	0.00	0.67	1.00	0.00	0.00	0.00
Young/brood	0.00	1.00	0.00	5.00	2.50	0.00	0.00	0.00
Vermilion River								
No. adult females	1	2	2	2	2	1	3	3
No. broods	0	2	1	2	1	0	2	1
Broods/female	0.00	1.00	0.50	1.00	0.50	0.00	0.67	0.33
Young/brood	0.00	3.00	6.00	2.50	7.00	0.00	3.00	3.00
Combined Streams								
No. females	5	10	11	11	12	5	12	10
No. broods	4	7	2	7	5	2	7	3
Broods/female	0.80	0.70	0.18	0.73	0.42	0.40	0.58	0.30
Young/brood	3.25	3.00	4.50	4.43	3.40	6.00	4.29	3.00